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ANALYSIS OF GPS ERRORS DURING DIFFERENT TIMES IN A DAY

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Abstract: *This paper focuses on modeling the errors which normally degrade the accuracy of Global Positioning System (GPS). The performance of the GPS is mainly affected by ionospheric errors. SiRF Star III single frequency receiver is used for collecting and projecting datum in World Geodetic System 1984 (WGS-84) co-ordinate form. To project the ellipsoidal model onto a map model, datum conversion from WGS-84 to Universal Transverse Mercator (UTM) form is needed. The conversion introduces errors in the datum. The variation in the errors can be observed from day to night, area to area and also due to the seasonal changes. The datum is collected from Ameerpet region of Hyderabad, which is a heavily populated area with heavy traffic and tall buildings. The variation in the datum has been observed from afternoon to evening.*

Keywords: *GPS, WGS-84, UTM, Northings and Eastings*

I. INTRODUCTION

Global Positioning System (GPS) is a satellite-based navigation and surveying system for determination of precise position and time, using radio signals from the satellites, in real time or post-processing mode [1]. It consists of a constellation of 28 satellites in six different orbits which give the information of the position of the GPS receiver user with sub meter accuracy. If there are four or more GPS satellites in unobstructed line of sight with the receiver, accurate spatial co-ordinates can be obtained [8]. The datum obtained from the satellites, contain the information about the position and timing by calculating the the Keplerian orbit elements [9]. The location information from GPS is based on the choice of coordinate system and datum [2]. The different types of errors that affect the performance of GPS are external errors like Ionospheric errors, Atmospheric errors, Satellite and Clocking errors, Multipath errors, Selective Availability and Anti Spoofing, of which the major error is the Ionospheric error in the radio propagation signal [4]. World Geodetic System 1984 (WGS84) is the datum used for GPS to describe a point anywhere on earth. WGS84 positions are in the form of XYZ Cartesian coordinates or latitude, longitude and ellipsoid height. The features of the Earth, which is a curved surface, when represented on a plane surface, spatial ad angular distortions occur. A function that converts ellipsoidal latitude and longitude coordinates to plane easting and northing coordinates is a map projection. Universal Transverse Mercator (UTM) is a worldwide mapping standard projection. The projected datum should provide the location of a receiver with minimal error [3]. The datum is acquired using a single channel GPS receiver from the overly crowded region of Ameerpet in Hyderabad and the variations in them are observed.

II. GPS ERRORS.

Development of townships, market yards, undeveloped sites etc., requires large scale maps for planning, design and implementation. These large scale maps require accurate and reliable GPS data [13]. The various errors in a GPS system are Orbital errors, Clock errors, Ionospheric errors, Multipath errors, Tropospheric errors, Receiver noise, Relativistic corrections, Dilution of Precision (DOP), etc… DOP indicates the influence of satellite geometry on position accuracy. The better the satellite geometry, the lesser will be the DOP and better will be the accuracy. The satellite geometry is assumed to be better if user-satellite unit vectors are more spread [12].

The ionospheric delay is the main problem in achieving millimeter level positioning [7]. These errors bias the receiver user's position to be ±15m from the actual coordinates [10]. Out of all these external errors, the Ionospheric error is the largest.

Besides the above mentioned errors, there are receiver internal errors, when there is a coordinate trans-formation from WGS 84 to UTM format.

III. CO-ORDINATE CONVERSION

The position of any place, object or point can be represented by means of its geographical co-ordinates expressed in three-dimensional form of Latitude, Longitude, and height. The Latitude and Longitude are

measured from the intersection of lines of prime meridian (passing through Greenwich) and the Equator. Similarly the height (or elevation) is normally measured from the mean sea level and is generally referred as "Above Mean Sea Level" or AMSL [11]. WGS 84 is the datum to which all GPS positioning information is referred in terms of latitude and longitude, by virtue of being the reference system of the broadcast GPS satellite ephemerides [5]. It is an angular coordinate system. UTM is a 2D geographical coordinate system which identifies the horizontal position of a user on earth independent of his vertical position. The UTM system is not a single map projection, instead it divides the Earth into sixty zones, each a six-degree band of longitude, and uses a secant transverse Mercator projection in each zone and is easier to employ than the WGS 84 system. UTM expresses coordinates in eastings and northings format. Easting corresponds to the number of meters a location is from the west side of the zone and Northing is the distance in meters from the Equator in the northern hemisphere [4]. The advantage of UTM over WGS-84 is its preservation of the shape of small areas on a map and its grid coordinates allow easy calculations using plane trigonometry. The coordinate transformation from WGS 84 to UTM is done using standard and direct conversion formulas as given by “A Guide to coordinate systems in Great Britain” [6].

IV. DATUM ACQUISITION

The datum is acquired by using a GPS receiver SiRF Star III. It is a micro controller chip which has 20 channels and obtains datum in WGS-84 co-ordinate system. The location selected for acquiring the data is Ameerpet, Hyderabad which has dense traffic and huge number of tall buildings. The datum is collected inside a building in the second floor in the morning, afternoon and evening hours with 40 samples at every instance.

V. RESULTS AND DISCUSSION

The datum obtained from Ameerpet is in the WGS-84 format (Φrx, λrx). This data is converted into UTM format (Nrx, Erx) by using the standard conversion algorithm as given in ‘A Guide to Coordinate System in Great Britain’ [6]. Then the variation in the data is observed.

The Latitude (Φrx) value in WGS-84 at Ameerpet during the morning between 10.00 am and 11.00 am got varied from 17.2588570 to 17.2590410. The variation in the values is high and gradually increasing in the morning. The longitude variation in the morning was from 78.26743 to 78.26745. The variation is less and is gradually increasing. After conversion to the UTM format, the Eastings (Erx) varied in the morning from $2.0935*10^5$ to $2.0936*10^5$ and for the Northing varied from $1.91831*10^6$ to $1.91839*10^6$ as shown in Figure1.

During afternoon the datum is collected between 1.00 pm and 2.00 pm and the latitude variation was between 17.2589480 and 17.2589740. The values have fewer variations in the afternoon as compared to morning and the values are gradually decreasing. The longitude

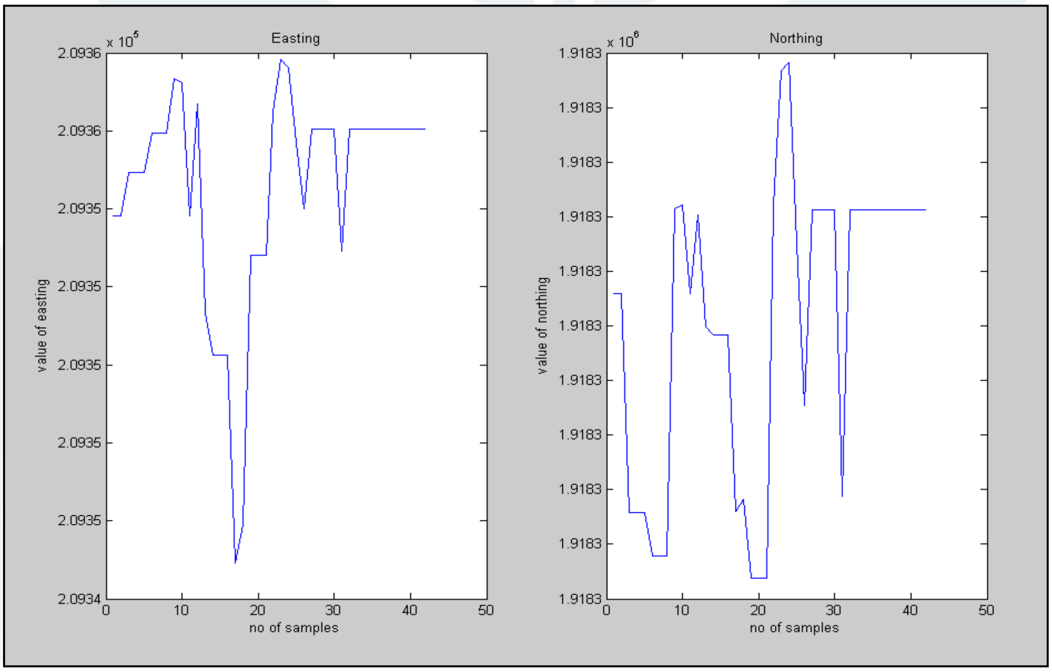

Figure1: The variation of UTM Easting and Northing values of Morning

values in the afternoon varied from 78.2675090 to 78.2674920 and the variation showed a steep decrease. The Afternoon variation of the easting values are less and were from $2.0937 *10^5$ to $2.0936 *10^5$ and Northing from $1.91831* 10^6$ to $1.91835* 10^6$ as viewed in Figure2.

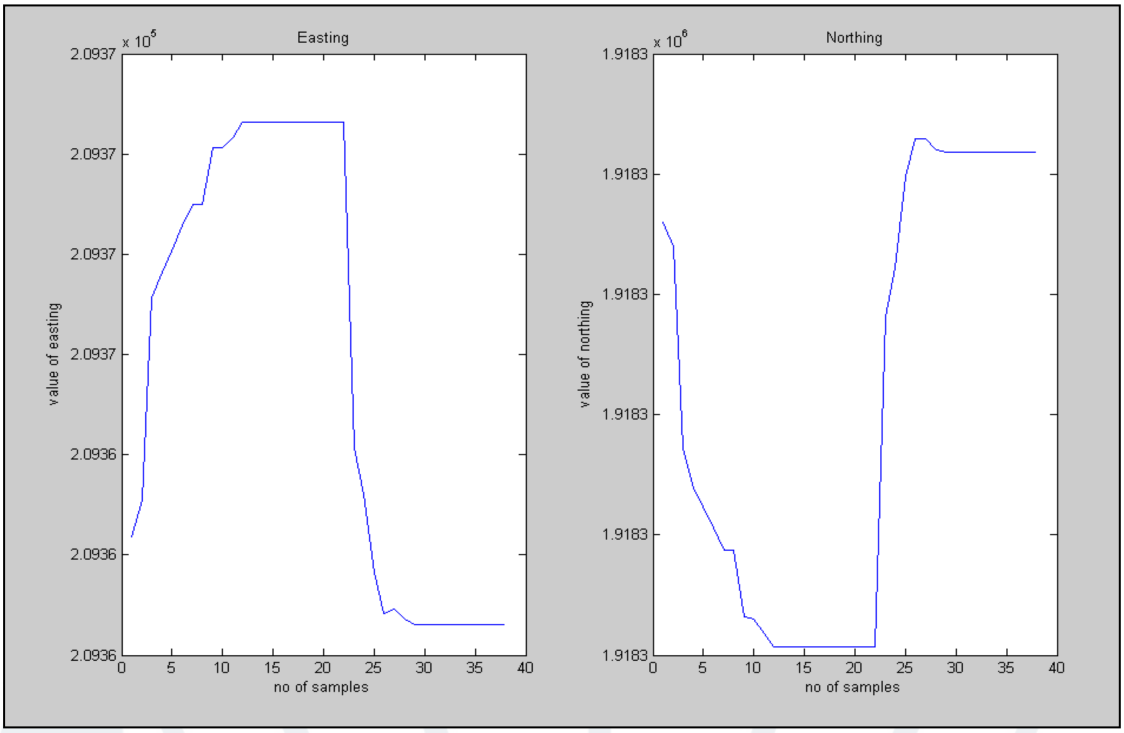

Figure2: The variation of UTM Easting and Northing values of Afternoon

The datum collected in the evening between 5 pm and 6 pm show a large variation of latitude from 17.2602500 to 17.2600780 as compared to morning and afternoon. The variation of longitude in the evening was from 78.2680890 to 78.2680270 and is not so high. In the evening the variation in the values are more when compared to morning and evening. Easting values varied from 2.09438 $*10^5$ to 2.09421$*10^5$ and the northing values varied from 1.91846$*$ 10^6 to 1.91841$*$ 10^6 as seen in the Figure3.

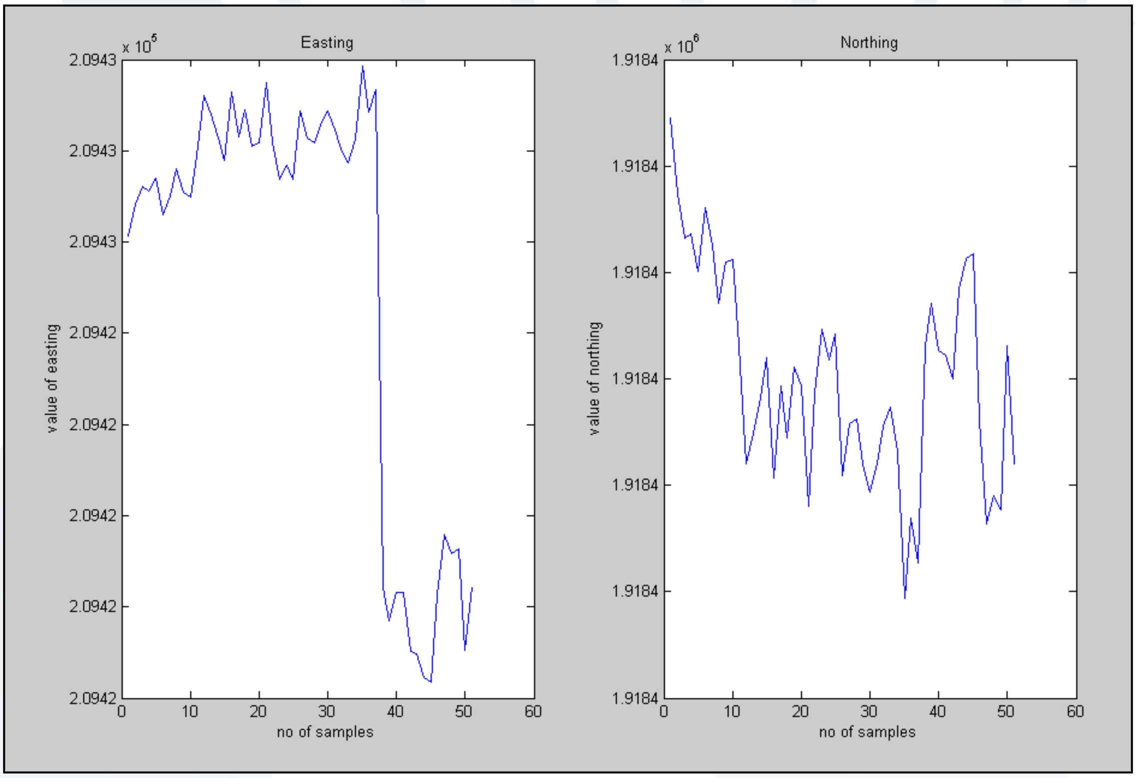

Figure3: The variation of UTM Easting and Northing values of Evening

If all the 120 samples of WGS-84 datum, collected throughout the day are observed, the longitude (λrx) variations are similar to that of the latitude variations in the morning and evening, whereas in the afternoon the variations are different. The entire UTM datum of northings and eastings obtained in the morning, afternoon and evening are plotted in a single graph as shown in figure 4. The variation between the morning and afternoon is not high but between afternoon and evening is high.

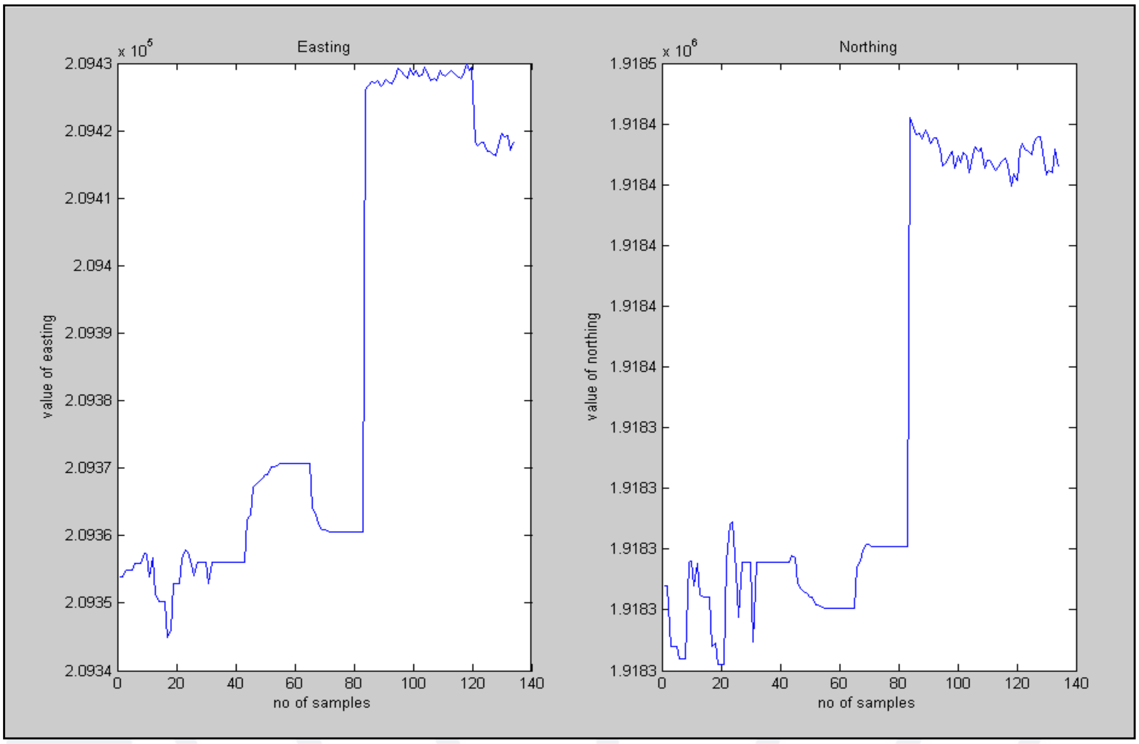

Figure4: The variation of UTM Easting and Northing of whole day

VI. CONCLUSION

The datum which is obtained from the GPS is prone to errors. The errors will be external and conversion errors. The errors which are external have been observed by viewing the datum which is obtained by the GPS receiver in the form of latitude and longitude. The variation in the values indicates the errors in the datum. The conversions from WGS-84 to UTM have also introduced errors. The errors are obtained due to the rounding up of the values in the algorithm.

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